UNIVERSITI PUTRA MALAYSIA

SEDIMENTATION DYNAMICS OF A SMALL HILL FOREST CATCHMENT IN ULU LANGAT, SELANGOR, MALAYSIA

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SEDIMENTATION DYNAMICS OF A SMALL HILL FOREST CATCHMENT IN ULU LANGAT, SELANGOR, MALAYSIA

By

SOULISACK DETPHACHANH

Thesis Submitted in Fulfilment of the Requirement for the Degree of Master of Science in the Faculty of Forestry Universiti Putra Malaysia

December 2000

To my wife, children,
parents and brothers

Abstract of thesis submitted to the Senate of the Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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This study assesses the sedimentation dynamics of a small hill forest catchment with an area of 2.6 km^2 in Ulu Langat Forest Reserve, Selangor, Malaysia. The study catchment was equipped with rainfall and water level recorder to assess the hydrological characteristics of the area.

The annual rainfall data recorded during the study period from July 1997 to June 1998 was 2051.6 mm. The maximum monthly rainfall of 431.4 mm was recorded in October 1997 while the minimum of 25.1 mm occurred in February 1998. In October-December of 1997 and May-June of 1998, high rainfalls were observed due to inter north-east monsoon and transition monsoon respectively.

Sedimentation dynamics in the study area was evaluated using the Helley-Smith bed load sampler and a two-weekly survey of stored sediment. Bed load was estimated using a bed load-rating curve and discharge time interval of half-hourly, hourly and daily mean values, there are the annual bed load was 4.61, 4.46 and 3.81 t respectively which presented about 17.0% of the total load.

Sediment deposition measurement was conducted fortnightly over a year showed the high sediment transported during two storms events. The sediment deposited about 3.064 t and 2.033 t during of 19 October to 1 November 1997 and 14 – 27 June 1998, compared with the annual load of 11.36 t, for the study period were transported.

The bed load particle size distribution is measured in order to determine the quality of the sediment transported. A wide range of particle size was observed. This ranged from 0.05 to 0.9 mm at D_5, 0.35 to 3.1 mm at D_{50} and 0.75 to 5.1 mm at D_{95} with average of 0.24, 1.1 and 2.16 mm, respectively.

Sedimentation dynamics was evaluated based on the bed load and sediment storage in the Sg. Pangsun watershed. High sediment loads were transported during storms, the proportion of the bed load and sediment storage load was year total: bed load versus sediment storage.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains.

PERUBAHAN PEMENDAPAN DI TADAHAN KECIL BERHUTAN BUKIT DI ULU LANGAT, SELANGOR, MALAYSIA

Oleh

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Disember 2000

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Penyelidikan ini mengkaji perubahan pemendapan di tadahan kecil berhutan bukit berkeluasan lebih kurang 2.6 km^2 persegi di Hutan Simpan Ulu Langat, Selangor, Malaysia. Kawasan penyelidikan ditengkapi dengan peralatan mengukur hujan dan paras air yang berujuan untuk menilai ciri hidrologi di kawasan kajian.

Data hujan tahunan yang direkod sepanjang waktu peyelidikan daribulan Julai 1997 hingga bulan June 1998 Talah 2051.6 mm. Didapati bahawa hujan bulanan maksimum talah 2051.6 mm aitu pada bulan Oktober 1997 manakala hujan bulanan minimum talah 25.1 mm pada bulan Oktober 1998. Dalam jangka masa Oktober-Disember 1997 dan Mei - Jun 1998, hujan yang tinggi dicatatkan masing-masing disebakan oleh musim monsun Timur Laut dan monsun peralihan.

Perubahan pemendapan di kawasan kajican dinilai dengan menggunakan pengambil contoh muatan dasar sungai Helley-Smith dan pengukuran simpanan endapan dilakukan setiap dua minggu sekali. Muatan dasar sungai dianggarkan dangan menggunakan garis lengkung perbezaan, satu jam dan nilai purata harian. Muatan dasar sungai tahunan talah 4.61, 4.46 dan 3.81 tan masing-masing yang mewakili lebih kurang 17.0% dari keseluruhan muatan.

Pengukuran endapan sungai yang dijalankan setiap dua minggu sekali selama satu tahun menunjukkan endapan yang tinggi yang didapati semasa dua kejadian ribut. Sebanjak lebih kurang 3.064 dan 2.033 tan diangkut dari 19 October sehinggi 1 November 1997 dan dari 14-27 Jun 1998, sehingga berjumlah 11.36 tan secara keseluruhanuya.

Penyebaran saiz partikel muatan dasar sugai diukur untuk menentkan kualiti dari endapan yang diangkut. Julat saiz partikel yang besar telah diperolehi. Julat saiz dari 0.05 sehingga 0.9 mm diperolehi pada D_5, 0.35 sehingga 3.1 mm pada D_{50} dan 0.75 sehingga 5.1 mm pada D_{95} dengan purata 0.24, 1.1 dan 2.16 mm masing-masing.

Perubahan pemendapan dinilai berdasarkan kepada muatan dasar sungai dan simpanan endapan di kawasan aliran sungai Pangsu. Muatan endapan yang tinggi didapati apabila terjadi ribut. Perbandigan muatan dasar sungai dan simpanan endapan taal jumlah tahun: muatan dasar melawan dengan simpanan endapan.

ACKNOWLEGEMENTS

I would like to express my profound gratitude to Assoc. Prof. Dr. Lai Food See, chairman of my supervisory committee, for this constant guidance, suggestions and encouragement throughout the preparation of thesis. I am highly indebted to my two other supervisors, Assoc. Prof. Kwok Chee Yan and Dr. Ahmad Ainuddin Nuruddin for invaluable suggestions and comments.

I would like also to take this opportunity to express my thanks to the Faculty of Forestry, Universiti Putra Malaysia for the permission given to undertake this study.

I am greatly thankful to Mr. Xame Samounty Director General of Lao-Forestry Department and Lao-Government, for granting me a scholarship and study leave to pursue this program.

I would also like to express deep gratitude to my father and mother, father and mother in law for all their support and encouragement during the course of this study and to my wife Ketkeo and my children, Toukta and Phouthasinh. I express my utmost gratitude to GOD, the invisible power, for providing me continuous flow of energy to undertake this study.

I certify that an Examination Committee met on 15 December 2000 to conduct the final examination of Soulisack Detphachanh on his Master of Science thesis entitled "Sedimentation Dynamics of a Small Hill Forest Catchment in Ulu Langat, Selangor, Malaysia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

SOULISACK DETPHACHANH

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LIST OF ABBREVIATIONS

°C	-	degree Celsius
3D	-	three dimension
C_1, C_2	-	catchment number (1) one and (2) two
cm	-	centimeter
DID	-	Drainage and Irrigation Department
FAO	-	Food and Agriculture Organization of the United Nations
g/cc or g/cm^3	-	gram per cubic centimeter
g/m^2/yr	-	gram per square meter per year
g/s	-	gram per second
ha	-	hectare
kg/s	-	kilogram per second
kg/s/m	-	kilogram per second per meter
km	-	kilometer
km/km^2	-	kilometer per square kilometer
km^2	-	square kilometer
LSFP	-	Lao-Swedish Forestry Programme
m	-	meter
m^3/km^2/yr	-	cubic meter per square kilometer per year
m^3/s	-	cubic meter per second
mg/l	-	miligrams per litre
ml	-	mililitre
mm	-	millimeter
mt	-	Metric tonne
ppm	-	part per million
SFAP	-	Selected Field Area Project
t	-	tonne
t/km^2/yr	-	ton per km^2 per year
TNB	-	Tenaga Nasional Berhad
UNESCO	-	United Nation Educational, Scientific and Cultural Organization
wt	-	weight

CHAPTER I

INTRODUCTION

The Malaysian tropical rain forest is species-rich, both in the lowland and hill areas. The total forested land in Malaysia is estimated to be 18.91 million ha or 57.5 % of total land area of 32.855 million ha (Tang, 1997). Of the 18.91 million ha, 16.41 million ha are Dipterocarp forests (86.8% of total forested land in the country) while the remaining 2.5 million ha and 0.7 million ha are freshwater swamps and mangrove forests respectively. The species rich tropical rainforest had, for centuries, afforded protective cover to keep soil erosion at low levels while sediment loads increased for most small and large rivers affected by land conversion, mining, urbanisation and forest practices. Competition for land in this part of the country has been largely for agriculture, in particular the rubber and oil palm industry.

Forests also play an equally important role in keeping the environmental balance and stability of the nation. On this, we often speak about the clean water and the rich aquatic life found in the streams flowing from forest catchments. The demand for water is growing at four percent annually and in year 2020, it will reach 20 billion m^3 (FAO, 1997). Rivers, which originate from forested watershed, provide about 97 per cent of the country's supply of clean water in Malaysia. Subsequently, its management, which hinges on the degree of forest protection in the up-stream, will become more crucial.

Presently, forest harvesting for timber resources occurs in hill areas of slopes of more than 20°. The encroachments of logging into the upper reaches have imposed great pressure on the environment.

Increasing soil deterioration, accelerated erosion and sediments in rivers are usually associated with vegetation removal in logging operations and land conversion for agriculture and development (Lai, *et al*., 1995). These activities contribute high concentrations of solid materials in streams which could directly or indirectly alter the physical, chemical and biological characteristics, in turn jeorpadizing the flora and fauna of aquatic systems (Zulkifli, *et al.,* 1987). Due to rapid deterioration of the ecosystem or forestland by such activities, the quality of forest streams has been continuously lowered.

Past studies had documented the effect of forest conversion on hydrological parameters (Bosch and Hewlett, 1982; DID, 1986; Abdul Rahim, 1987). The effect of partial forest removal or selective logging, which generally forms the basis for sustainable forest management particularly in the humid tropics, on the hydrological parameters had also been widely reviewed. (Zuklifli Yusop, *et al*., 1987; Baharuddin Kasran, 1988; Abdul Rahim and Harding, 1992).

Problem Statement

Uncontrolled erosion pose environmental problems because it removes productive topsoil, damage roads and fields by gullying and landsliding, cause eutrophication and silting of river channels and reservoirs. Such environmental degradation can only be stopped with great effort and cost. Yet erosion is a complicated phenomenon, a result of many processes. The number of factors and their interactions limit our ability to predict rates of erosion, although we know that the most important factor influence soil erosion are climate, vegetation, soil characteristics, topography and land use.

The study of erosion and sediment yield from river basins is important for many reasons. Among them is deposition of sediment in a reservoir, which reduces its capacity thereby adversely, affecting water supply for irrigation, domestic and industrial use, and power generation.

Sediment yields are essentially products of overall interaction between water and the total biochemical and physical characteristics of the catchment. If accurately quantified, they reflect the basin dynamics well. For example, in Malaysia, information on sediment yield have been reported in the past (e.g. Douglas, 1968, 1990; Peh, 1981; Lai, 1993, 1995; Baharuddin, 1988), but few reported on the dynamics of sediment transport of hill catchments.

Studies of sedimentation dynamics of hilly watershed in tropics are also few. Research is therefore needed to develop the necessary monitoring and modelling strategies to improve our understanding of the sediment transport processes involved.

Sedimentation dynamics – is defined as the sediment movement with emphasis on sediment transport as controlled by basin morphology; sediment availability; storm character and timing, and stream power magnitude.

Objective of Study

The general objective of the study is to examine the sedimentation dynamics of a hill forest watershed. The scope of work involved determination of:

i) the hydrology of the study basin, specifically with respect to rainfall and runoff.

ii) sediment transport in the study stream with emphasis on bed load and,

iii) bed sediment particle size.

Summary

Erosion and sediment in streams is a complicated phenomenon because many processes are involved. To unravel some of the problems addressed in the proceeding sections, the relationship between output of bed materials with the prevailing hydrological conditions will be examined in detail, using essential equipment and measuring procedures.

CHAPTER II

LITERATURE REVIEW

Introduction

This chapter presents an overview of past studies related to sediment yield and sedimentation of hill tropical forest catchments.

Sediment Related Hydrological Processes in Forest Watersheds

Hydrology is concerned with the circulation of water and its constituents through the hydrologic cycle. It deals with precipitation, evaporation, infiltration, groundwater flow, runoff and streamflow. The output of erosion within a catchment is known as sediment yield. It can be defined as the amount of sediment transported from a catchment over a specific time interval.

High sediment yield is associated with regions in arid, semiarid, seasonal Mediterranean and the tropics (Walling and Webb, 1983). A compilation of sediment yield for meso scale drainage basins by Reid and Frostick (1987) suggests that arid basins export 36 times more material than humid temperate basins and 21 times more than humid tropical equivalents.

Hydrologic characteristics of the soil, such as infiltration capacity and moisture content may control the amount of water that enters the soil. These are in turn affected by texture, structure, and organic content of the soil. High infiltration capacities are generally associated with sandy or heavy soil (high silt and clay content) that has a well-developed crumb structure (fine particles held together as aggregates). If such a soil is exposed to the beating action of raindrops, the aggregates are broken up with fine materials sealing the surface, thereby greatly reducing infiltration capacity.

Streamflow is the major output of the stream system in a watershed. Accurate measurement of streamflow is necessary for estimating sediment load since the relationship between runoff and sediment is usually a direct one.

Sediment Sources

Sediment is the fragmented material produced from chemical or physical disintegration of rocks. Mass erosion, especially from the streambank collapse, and rainfall impact along the stream course also appeared to be the major contributors of sediments. (Fleming and Poodle 1970; Berg 1986; Burgess 1971; Brown and Krygier, 1971; Langford and O'shaughnessy 1977; Cornish 1980 and Veracion 1983). Human actions, for example timber harvesting operations in forest catchments, logging road and skid trail construction are the main sources of sediment production (Beschta, 1978).

Accelerated erosion can result in heavy river sediment content and shallowing of streams. Many studies reported that surface soil erosion is the main source of sediment in streams while erosion in streams usually occurs along channel beds (Eyles, 1970; Douglas, 1970; Morgan, 1977).

Sediment yield from drainage basins provides a useful index of erosion severity and trends. However, land development managers need more information about sediment sources and processes in value in mobilization of sediment, and also the relation between erosion intensity and controlling factors.

According to Singhal *et al.,* (1981), all sediment comes from:

1) Sheet erosion of land surface - the removal of material from surface by forces of rain drops impact and surface runoff or wind action.
2) Gullying - gullies are channels more than 15 cm deep, eroded by concentrated runoff in the soil or on unconsolidated rock.
3) Stream channel erosion - this is erosion of banks and scouring of beds and streams.
4) Flood erosion, construction erosion, mining, and industrial waters.
5) Mass movement - these include landslides, stumps, avalanches and creeps

While erosion and sedimentation are often viewed negatively from a biological point of view, they are essential to the ecological functioning of aquatic and terrestrial communities because they provide the sources and the surfaces necessary for habitat. In